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PSYCHOPHYSICAL MEASUREMENT METHODS.

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The period of approximately seven years since the last review of this field by Ruger (140) in 1918 has been marked by an increased interest in psychophysical methods and psychophysical laws. This increased interest has been marked not only by contributions to the fundamental bases of psychophysical procedure, as well as a large number of studies in the traditional field of sensory measurement, but more especially by the application of psychophysical methods, concepts and laws to the solution of new problems, new problems in the field of sensation, problems in other fields of psychology, and even problems in other sciences. In his laboratory manual, Pauli (115) includes a considerable number of psychophysical experiments, both in a section devoted to psychophysics and in the sections dealing with the senses. Lipps (100) publishes a third and enlarged edition of his "*Grundriss der Psychophysik.*" Titchener (152) gives a résumé of Mach's little known lectures on psychophysics. Kantor (83) believes that the psychophysical experiment may offer a basis for the reconciliation of opposing points of view in psychology (behaviorist and introspectionist). The analyses of this experiment from the two standpoints agree as to the initial event, the stimulus, and the final event, the verbal response. The intermediate terms are similar in name, but differently interpreted. If the introspectionists will abandon their supposedly epistemological background and become behavioristic in their interpretation of the psychophysical experiment, they and the behaviorists may be reconciled to one another.

Theoretical Considerations

Boring (11, 12) analyzes the logical basis of the use of the normal law in mental measurement. While the argument is concerned in large part with the use of the normal or Gaussian Law in the field of mental tests, it also has most important bearings upon psychophysics. Boring considers first the nature of probability and finds that it is not possible to establish the law of probability upon a deductive basis. The law is based upon ignorance, the absence of any reason why it should not hold, not upon cogent reason. Turning to the law of error, he finds that it is grounded upon definite assumptions, but that those who apply the law to particular cases do so uncritically, often failing to note whether or not the data treated are subsumed under the assumptions. The normal law of error has become a fetish, to which attempts are made to fit all data. But a long series of observations has shown that the law does not have the universal validity attributed to it. Boring shows elsewhere (13) that a distribution of the heights of 221,819 men is not "normal." As is evident in both psychometric functions and mental tests, the distribution obtained depends upon the unit used, so that in any mental measurement the form of distribution cannot be determined *a priori*. Thus Boring comes to the conclusion that there are not available any strictly psychological units save the sense distance, and it has not proved fruitful. Physical units (of stimulus or of behavior) are frequently used, but physically equal quantities or intervals are not psychologically equal. The only quantities left to the psychologist are rank orders of psychological quantities given with reference to an extrapsychological scale. Kelley (85) objects to this position because the logic of probability is a matter of inductive, not of deductive reasoning. He holds that probabilities are established as a result of previously observed frequencies, so that in the setting up of probabilities the evaluation of preceding experiences is the starting point in the process of increasing knowledge at the expense of ignorance. Kelley also points out that Boring's claim that the form of the distribution depends upon the unit of measurement does not hold true if the units are linearly related, but fails to realize that the type of relationship which Boring was considering (the common type in psychophysics) is nonlinear.

Boring (10) also calls attention to the fact that in psychological experiments one often obtains a mathematical value for the significance of the experimental result which seems to be "too high." The result is mathematically significant, but may not be scientifically

significant. This is because the experimentally obtained result is always the product of sampling and the scientist may feel that the sample does not adequately represent the phenomena to be described. The result obtained lacks scientific significance, not for the sample group, but for the larger group of which the sample is taken. Whether or not a result is significant is thus a matter of scientific intuition. Kelley (**85**) takes exception to this conclusion, holding that intuition is not a method of proof and that to disregard mathematical results is scientifically dishonest, for it means keeping and using data if they support an established conviction and otherwise discarding them.

Urban's "*Grundlagen der Wahrscheinlichkeitsrechnung und der Theorie der Beobachtungsfehler*" (**156**) has been reviewed in detail elsewhere in the BULLETIN (**21**, pp. 235–239). In it and in a more recent paper (**158**) Urban considers the relation between psychophysics and the theory of errors of observation. Klein demonstrated the existence in all physical measurements of a margin or interval within which all values of the standard of measurement appear equal to the unknown quantity, a margin which is determined by the quality of the instruments used and the accuracy of the observer's sense organs. It is customary to take the center of this margin, the mean of its upper and lower limits, as the value of the quantity to be measured. The margin corresponds to the interval of uncertainty in psychophysics and the central value to the point of subjective equality, while the process used to determine the upper and lower limits is identical with the one followed in the method of least perceptible differences. The finding of psychophysical experimentation, that the point of subjective equality (crossing of the psychometric functions) is the center of the interval of uncertainty, aids in the justification of the method of least squares as a means of adjusting physical observations.

Thomson (**150**, **22**, p. 75f) questions the use of the interval of uncertainty (with "equal" judgments admitted and the threshold placed at 50 per cent) because it is a measure of a moral characteristic rather than one of physical sensitivity, since the observer can vary it according as he determines to give or not to give "equal" judgments. Instead, he suggests the interquartile range (75 per cent "greater" to 75 per cent "less," with no "equal" judgments) as a measure of sensitivity, with no determination of the limen. A comparison of results obtained by the two methods would throw light upon the explanation of Weber's Law. Boring (**14**) takes an opposite

stand on this issue. He holds that accurate control of the observer's attitude in a series of psychophysical experiments is both possible and scientifically necessary. Doubt, expectation and reflective judgments must be eliminated, largely by the establishment of definite serial categories of judgment and by the isolation of the single judgment, since Fernberger (**40**, **41**) has shown that every judgment is influenced by the preceding report.

Mathematical Treatment

The outstanding contribution in recent years to the mathematical phase of psychophysics is the second edition of Brown's "*Essentials of Mental Measurement*," brought out in collaboration with Thomson (**22**). As this volume is the subject of a special review in the Bulletin (**20**, pp. 450–453), we can at this time only note the range of topics discussed which lie in the field of psychophysics. The first chapter considers such fundamental problems as the nature of mental measurements, the scale upon which such measurements can be made, and the nature and interpretation of Weber's Law. It is followed by a treatment of the elements of the mathematical theory of probability. The third chapter contains a more or less detailed account of each of the psychophysical methods. The constant method is given the major consideration, and the various mathematical devices for computing limens and measures of dispersion from the data obtained by it are taken up individually. Then follows a chapter on skewness and heterogeneity. Here Thompson applies Pearson's theory of curve fitting to psychophysical data, using both the Pearsonian skew curves and combinations of normal curves. He comes to the conclusion that his illustrative data are probably not homogeneous in character. The important contribution is the method of treatment, which is more extensive than that previously used in psychophysics. The remainder of the book is concerned with problems of correlation.

Two separately published papers by Thomson deserve mention. In one of these (**148**, see also **22**, pp. 77–81), Pearson's method for testing for goodness of fit of curves is applied to data obtained by the constant method. This criterion differs from the one previously used by Urban to test the adequacy of various hypotheses in that it depends upon the weighted instead of the raw squares of the differences between observed and theoretical values, that the end result is expressed as a percent probability, and that a well fitting curve gives a high instead of a low value. In the other paper (**149**),

Thomson reviews the history of the Fechner-Müller-Urban process of computing the limen from the constant method (the *phi-gamma* hypothesis). He then deduces the same formulæ directly from the assumptions that for every stimulus there is a constant probability that the reaction in question will occur, that these probabilities are functions of the stimulus given by the integral of the normal probability curve, and that the observed values differ so little from the true probabilities that certain mathematical approximations may be made. This paper is especially valuable to the inquiring psychologist who has been unable to follow the logic and the mathematics of Urban and his predecessors.

Kelley (**84**, p. 373ff) publishes the "*Kelley-Wood Table of the Normal Probability Integral*" and shows (pp. 326–329) how it may be used in the computation of limens by the constant process. For this purpose he derives formulæ in terms of the variables of his table and shows that they are identical with those of Fechner, Müller and Urban. The Kelley-Wood Table has the advantage of reading to three decimal places (as against the two places of earlier tables), but its use involves the lengthy computations which are avoided in Urban's Tables.

Two devices for shortening the tasks involved in computation have appeared. Rich (**135**) prints a checking table to be used in connection with Urban's Tables for rapid checking of the necessary additions. Hoisington (**82**) contributes a table for the graphic check of the constant process with the least possible computation. It is a table of the probability integral arranged for this special purpose. It is also useful in computing the goodness of fit of psychometric curves according to either Thomson's (**148**) or Urban's method whenever the *phi-gamma* hypothesis is involved. Boring (**17**), Rich (**137**) and Davies (**32**) note errors in Urban's Tables and the necessary changes in Rich's Checking Table.

Urban (**157**) calls attention to observations by Hoisington and Thomson which indicate that the agreement between the observed values in a psychological experiment and the values computed according to the *phi-gamma* hypothesis tends to increase with practice. He suggests that this relationship could be worked out in detail from data already extant. Fernberger (**46**), acting upon this suggestion, computed the sums of the squares of the differences between observed and calculated values for two series of experiments with lifted weights. The sums of the squares of the deviations of theory from actuality appear to decrease with practice, although the change is not marked,

as the observers were highly practiced before commencing the experiments. Unfortunately, Fernberger failed to use the more satisfactory criterion for closeness of approximation of a curve to observed data that Thomson (48) has furnished. Boring (18) objects to Fernberger's conclusions on the ground that his figures do not actually show any effect of practice. Straight lines adjusted (by the method of least squares) to the values for the sums of the squares of the differences show increased approximation with practice in only two of the four cases, and the opposite effect in the other two cases. Boring thinks that this result is to be expected. Urban is trying to find in the *phi-gamma* hypothesis a generalized psychometric function. Such a function is impossible. No hypothesis can be general because it must always depend upon the unit of measurement.

Tinker (151) reports an experiment in the psychology of curve fitting. His observers were given the task of drawing the best fitting straight line through a number of points on coördinate paper. Although the observers did not work by or think in terms of least squares, their average results closely approximated the line of least squares. The psychology of adjustment appeared to be in part emphatic, but included the idea of equation of unsquared positive and negative deviations. An experiment of this type shows the inherent logical and psychological difficulties experienced in arriving at a satisfactory notion of what constitutes agreement in a curve fitting.

Weber's Law

Both the experimental and the interpretive consideration of Weber's Law have continued during the period under review. Harrison (75) prepared a series of colorimetric standards with solutions of safranin, starting with a concentration just visible and proceeding by steps just perceptible to the unaided eye. The increments in concentration required to accomplish this approached very closely to a geometrical progression, so closely that a calculated geometrical progression gave a Pearsonian correlation of .99 with the observed series. Similar results were obtained with solutions of luteol, methyl orange, malachite green and Bismark brown. Kiesow (88) reports the results of experiments by Gatti (56) and himself (87) upon the stimulation of hair-spots and concludes that Weber's Law holds, with a relative DL of about 1/7, within a middle range of stimulation. Putter (126) determined the DL for vision and found it to be an exponential function of the stimulus. He concludes that the Weber-Fechner Law is wrong and suggests that the intensity of

a sensation is proportional to the concentration of the irritable substance in the receptive system, a concentration which is an exponential function of the intensity of the stimulus. He further shows (**127**) that this chemical theory of stimulation may be applied to all living systems and to all stimuli which act by causing a quantitative, but not a qualitative alteration of the metabolism of the tissues affected. The phenomena of adaptation and after-image (**128, 129**) can be explained by the theory. In a later paper (**130**), Putter reports an investigation of the DL for temperature and finds that it follows his exponential law, not Weber's Law. Bühler (**23**) discusses and interprets Putter's results and conclusions. Fodor and Happisch (**50**) found that Putter's Law describes more adequately the relation of the DL to the stimulus in taste than does Weber's Law. Hansen (**74**) found that Weber's Law holds only partially for pressure sensations.

Chaffee, Bovie and Hampson (**26**) studied the electrical reponse of an excised frog's eye when stimulated by light. They found that for low intensities the response varies as the square root of the stimulus, while for medium intensities it varies as the logarithm of the stimulus. These results are interesting in that they offer a partial reconciliation of Cattell's and Fechner's formulæ for the relation of stimulus and sensation, each holding true within a limited range. Further investigation in line with this suggestion, that the psychophysical relation is to be expressed by a combination of two or more mathematical functions, merits attention. Since the response measured in this experiment was a physiological and not a psychological one (it involved no central factors), the data also cast light upon the interpretation of any psychophysical law. Schjelderup (**141**) discusses the theory of stimulation of the retina and from it deduces a new formula for the relation of sensation to stimulus, together with a corollary for the value of the DL. He then compares the values of the DL found by a number of investigators with those computed by his formula and finds very close agreement between the two series. The relationship is too complicated to be characterized by a single term such as 'logarithmic' or 'exponential.' It is purely algebraic (nontranscendental).

Dingler and Pauli (**36, 116**) find that logarithmic correlations occur in all sorts of bodily (plant and animal) and mental responses far more frequently than any other numerical relationship. These facts may be summarized in a general law of relativity, which applies the logarithmic relation of rapid rise at low intensities and slower increase at higher intensities to bodily and mental processes of

response to stimulus and of growth. The biological importance of this relativity is found in that it contributes to the conservation of life by permitting an advantageous state to be attained comparatively quickly, yet causing a harmful state to be reached but slowly. To find an explanation of the Weber-Fechner Law, the process of excitation must be considered as a unit. It can only be explained in terms of the coöperation of a large number of individual physico-chemical processes, such as the law of mass action and osmotic-electrolytic effects. Pikler (121) restates Weber's Law in terms of his adaptive theory of sensory processes, the details of which cannot be considered here.

Bourdon (20) discusses Fechner's formula for Weber's Law and tries to show that the distinction between stimulus and sensation is an error. Both are alike, one and the same thing. Pradines (123) holds that the interesting part of Weber's Law is not consciousness of difference, but the fact that changes are, for a time, unconscious. The law should be stated: "Our unconsciousness of intensity increases with the intensity." The facts of the law and the exceptions to it are partly to be explained by some kind of activity which consciousness exerts towards the increments of intensity. Mark (104) considers the general phenomenon of the limen and its meaning for psychology; the qualitative and quantitative DL's for sound; and the importance of these limens for hearing. He interprets the RL as purely physiological and the DL as in part physiological and in part psychological. Bonaventura (7) discusses the importance of psychophysics for various branches of psychology. He believes the criteria of judgment in psychophysical experiments have been chosen rationally rather than empirically. Pieron (120) describes the widespread application of the Weber-Fechner Law in various biological fields and shows some of the implications of this law for the biological sciences.

Effects of Special Conditions

The effect of attitude upon the psychophysical judgment has received particular attention. Boring (15, 16) discusses the so-called stimulus error. He first traces the development of the notion of a quantitative psychology and the objections raised thereto. The psychology of capacity attempted to meet these objections by abandoning mental magnitudes and measuring the capacity of the organism for response. The older psychophysics sought to protect itself against incursions of the physical attitude of the psychologists of capacity

by styling that attitude the stimulus error. The implication would be that a psychology of capacity should cultivate rather than avoid the stimulus error. " The thesis of this paper is, however, that recent researches have shown that the observational attitude which is directed upon the stimulus—the attitude of the stimulus error—may sometimes lead to equivocal correlations of stimulus and response which, because equivocal, are unscientific. In the case of the limen of dual impression on the skin, for example, a psychology of capacity must make use of introspective data if it is to attain its own ideals."

Friedlander (**53**), working upon the perception of weights placed on the skin, found that it was possible to take two attitudes toward the experience, an attitude of attention to the sensations and an attitude of attention to the lifted object. Determinations of the DL under the two attitudes showed the limen to be somewhat smaller under the object attitude than under the sensation attitude. In a second experiment performed by means of an esthesiometer an opposite result was obtained, but in this case the observer was unable to objectify the pressure and the instructions to do so acted as a distraction. Fernberger (**44**) used a similar method in an experimental study of the stimulus error in the case of lifted weights. He determined the DL under three sets of instructions: to report only upon the intensity of the pressure sensations in the fingers; to judge the intensity of the kinesthetic sensations set up in the wrist; and to judge the weights themselves. The psychometric functions and limens obtained vary between the different instructions. The pressure and kinesthetic instructions give rise to strictly psychological results, while the stimulus attitude leads to an equivocal sort of judgment which, because of its low degree of subjective assurance, tends to yield a large threshold. The author's final conclusion that " This experiment seems to show the futility of properly interpreting the statistical results of a purely behavioristic experiment " called forth discussion by Weiss (**161**) and a reply by Fernberger (**45**) which exhibit the wide differences between the attitudes of the introspectionist and the behaviorist toward a psychophysical experiment, both as to purpose and interpretation. Reid (**133**) practically repeated Fernberger's experiment, obtaining copious introspections from the observers under each set of instructions. He considers the thresholds and measures of precision obtained in the light of the introspective reports of criteria of judgment, reports which showed that in a majority of cases the instructions were contaminated or exceeded. The statistical data are treated qualitatively by being rearranged under the

the types of judgment the observer reported giving instead of under the types to which they should have belonged had the instructions been successful in producing the desired attitude. Of the three bases of judgment, the attitude of judging the weights as objects gives the most accurate results. It affords a more stable basis of judgment than does pressure pattern in the fingers; and this in turn a more stable basis than pressure pattern in the wrist. Garrison (**55**) reports a companion study of differential thresholds for extent of arm movement under two instructions; to judge objectively the distance through which the observer's arm moved; and to judge in terms of the pressure pattern these movements set up in the elbow. He finds that a change of instructions does not necessarily bring about a change of attitude in the observer. The limens are relatively larger under the object instruction than under the pattern instruction, but the difference tends to disappear with practice. There is little difference in the coefficient of precision.

Philippe (**118**) investigated the effect of the observer's knowledge of the stimulus upon the cutaneous perception in the two-point limen. A blindfolded observer neither perceives two discrete points nor is able to characterize the perception by reference to object. When he knows something about the stimulus, the observer describes intermediate patterns similar to those found by Friedline (**54**) and others. Travis (**154**) studied the effect of abstraction upon the intensive RL for tones. Determinations were made under normal conditions and when the observer was gazing into a crystal and recalling some pleasant experience as a starting point for revery. The results are equivocal, an increase in the threshold for four of the ten observers, a decrease for four of them, and no effect for the other two. Bates (**3**), in her study of the Müller-Lyer illusion, attempts to make objective measurements of attitudinal change. The variables are the brightness of the wings and the instructions to the observers. The effect of a shift of instructions upon the observer's attitude can be stated in terms of the variation in wing brightness necessary to bring about an equal change in the amount of the illusion.

Fernberger (**40, 41**) reports an experiment upon the DL for lifted weights in which the two middle pairs of stimuli (96 g. and 100 g.) followed either an 88 g. or 104 g. pair. He finds that, "There is present, in the method of constant stimuli as applied to lifted weights, a constant effect between the pairs of stimuli. If a comparison stimulus, which is likely to fall within the interval of uncertainty, immediately follows the lightest pair, for which, of

course, the judgment is usually 'lighter,' there is a strong tendency that it will be judged 'heavier.' If it follows the heaviest pair—which usually gives the judgment 'heavier'—there is an equal tendency that it will be judged 'lighter.' The presence of this factor of contrast causes a distortion of the curves for the psychometric functions. . . . It has a slight effect upon the size of the interval of uncertainty and a very marked effect upon the position of the thresholds and the point of subjective equality. There seems to be a slight tendency for this factor of contrast to increase with practice. It seems doubtful if simple instructions given the observer will eliminate this factor. . . . A method of eliminating the effects of the factor . . . by handling the objective relations of the stimuli themselves is suggested." Borak (**8**) shows that in the case of the DL for pressure (weight on forearm) there is a greater sensitivity to increase of weight than to decrease of weight. The limen is smaller in ascending than in descending series, but within such type of series it seems to follow Weber's Law. Central as well as peripheral factors are involved in these results, since change change in the weight is a stimulus to muscular action. Geissler (**57**) studied the effect of expectation on judgments of sound intensity and of visual extent. His results show that the variable is the more over- or under-estimated the more it differs from the expected stimulus, the tendencies to err being always in the direction of the expected standard. The tendency to error is larger when the standard to be expected is also previously given in perception than when it is merely imaginally anticipated. Tittel (**153**) investigated the effect upon the DL for successive fork tones of an inducing stimulus which preceded the standard. Assimilation occurs when the interval between the inducing and the standard stimuli is less than an octave and contrast when it is greater than an octave, with the exception that assimilation appears with all consonant intervals for musical observers. Tittel believes induction to be centrally conditioned.

Herrmann experimented upon the effect of a group, which formed an obscure background, on the successive comparison of horizontal lines. The tendency to form a mean idea of the group bore more heavily on the first than on the second stimulus shown. There were also tendencies to form means of subgroups. Gelb and Granit (**58**) determined the chromatic RL by means of a disc of colored light thrown upon a colorless figure (cross) or upon the ground of the figure (remainder of a larger disc). The results indicate that the color limen is higher for the figure than for the ground, and that

the difference is greater the more striking the difference between figure and ground. Incomplete experiments point to a smiilar dependence of the DL for brightness upon the figure-ground difference.

Bush and Austin (25) determined the DL for pressure on the hand and for tension from the wrist at three standards by allowing water to flow continuously into a beaker and having the observers report when the beaker felt heavier than it had been. With water flowing into the beaker at different rates, it was found that the limen is smallest for slow rates of increase, but that the time from the beginning of the increase of weight until the threshold is reached is least for the fastest rates of flow.

Chiba (27) studied the relation of differential sensitivity above and below the standard stimulus. Results of experiments upon the DL's for pitch and light intensity, as well as discriminative reactions to pressure intensities, indicate that discrimination is better above the standard than below it. This asymmetry is primarily a matter of relativity or contrast. Gertz (160) investigated the effect of adaptation upon the DL for temperature. The DL decreases the nearer the standard stimulus approaches the temperature to which the skin is adapted.

Putter (126) found that the intensity of stimulus necessary for liminal stimulation of the eye is an exponential function of the length of stimulus up to .5 sec. Fodor and Happisch (51) worked on the effect of the interval between stimuli upon the DL for the brightness of two flashes of light. When the stimuli are of the same intensity, the percentage of " brighter " judgments increases as the time interval is increased. The time interval at which the second is judged as brighter is inversely proportional to the intensity of the stimulus. Working with objectively equal stimuli by the constant method, they found the liminal time interval (schwellenzeit) at which 50 per cent of the judgments would be " brighter." In the case of the DL for taste (NaCl), they had found that increasing the time between the stimuli raised the limen, but that it increased the lower more than the upper DL.

Vision

Cobb and Loring (30) describe a method of measuring the threshold of retinal sensitivity in which a very small and fixed extent is exposed tachistoscopically for a measured length of time. The stimulus is physically a negative one since it appears as a black dot on a white screen. The limen, in terms of time of exposure

as conditioned upon area of stimulus, was determined by the method of serial groups, computed by linear interpolation. The time of liminal exposure multiplied by the area of the stimulus was approximately constant. Cobb (**29**) found this relation to hold for large as well as small stimuli, although there were individual variations in the sensitivity of his observers. He also describes (**28**) the use of these threshold measurements in routine examinations for air service. Reeves (**132**) reports experiments showing a greater sensitivity to brightness and brightness discrimination under dark adaptation for binocular than for monocular vision. Müller (**108**), however, finds opposite results, that the RL for dark adapted eyes is the same for both types of observation.

Hecht (**78**) studied the differential sensitivity to light of *Mya arenaria*, as indicated by retraction of its siphon in response to an increase in illumination. The relative DL shows the same course as for the human eye, a decrease up to a certain point and then an increase. From the chemical point of view, it is evident that for the retinal elements to discriminate between one intensity and the next perceptible one the transition from one to the other must involve the decomposition of a constant amount of photosensitive material. The magnitude of this increment is greater for the rods than for the cones. This fact results in a shift in the general course of the DL between rod and cone vision. Griffitts and Baumgartner (**66**) determined visual acuity by the observer's brightness discrimination in setting a Lummer-Brodhun photometer (approximately a method of average error). Visualization of the same observers was tested by the solution of geometrical puzzles. A small but positive correlation was found between these two characteristics. Bishop (**5**) describes an apparatus for the presentation in rapid succession of colored stimuli (painted surfaces) in determinations of visual DL's and RL's. The visual experiments of Putter (**126**) and Gelb and Granit (**58**) have already been considered.

Young (**164**) tested the chromatic thresholds for B, R, G and Y by making up solutions of dyes and dropping one drop on blotting paper. The observer was given a series of these papers and asked to name the color. Threshold values for normal and diseased persons are given in terms of strength of solution. Ferree and Rand (**47**) give measurements of the chromatic threshold, in terms of the intensity of light necessary to recognize the color, from the center to the periphery of the retina. No constant ratio between color pairs, as would be expected from the Hering theory, is found. The general

bearing of the results upon color theory is discussed. Dimmick (35) determined chromatic limens for R, G, B, Y, Bk and W, as differentiated from a middle gray, using colored papers. The limens were all of approximately the same magnitude. Dimmick uses this fact as evidence that the gray-black and gray-white sensory series are similar in nature to the sensory series from gray to a color. Haupt (76) used monochromatic spectral light to ascertain the chromatic RL at seven points on the spectrum and the number of j. n. d.'s between the lower and upper chromatic thresholds at each of the four primary colors. Liminal chromatic sensitivity increased in the order: O, R, Y, BG, B, YG and Y, with dark surroundings, and in the order: O, Y, R, YG, B, G and BG, with light surroundings. Elliott, West and Hoisington (37) determined the chromatic thresholds for film colors of the four principal hues. Film colors were produced by having the observer view the color through a small hole in a gray screen of the same brightness as the color to be observed. The size of the hole was kept constant and the relative size of the color varied by shifting the distance of the observer from the apparatus. The limen, in terms of visual angle, is about the same for R and G and for B and Y, the latter being nearly twice the former. Ginsberg and Hoisington (63) utilized a similar method to compare the relative saturations of a surface and a film color. The surface color was used as the standard and differential thresholds obtained for the film color in terms of visual angle.

Laurens and Hamilton (99) determined the DL for hue throughout the spectrum. The stimuli were pairs of spectral lights presented simultaneously. The number of visible hues (j. n. d.'s) was found to vary from 161 to 207. The threshold is smallest in Y and BG, with secondary minima in O, V and G. "There is a decided shift in the names applied to spectral wave-lengths due to successive induction, and thus depending upon which direction the spectrum is scaled. No such shift is observable in regions of minimum threshold." When colors are set so as to be just noticeably different they sometimes and at some wave-lengths appear more different from each other than they do at other times or at other wave-lengths. "This subjective fact bears no relation to the physical value of the threshold . . . but it casts doubt upon the value of the 'least perceptible difference' as a psychophysical unit." In a second paper, Hamilton and Laurens (73) determine similar discrimination curves after fatiguing the eye to R, G or B by 30 seconds' exposure (repeated for each observation) to homogeneous light. The curve

obtained for red-fatigue is essentially that of a protanope (red-blind), that for green-fatigue of a deuteranope (green-blind). Data were lacking for comparison with a tritanope (blue-blind). The authors consider that they produced artificial color-blindness by fatiguing the eye to these colors. Fatigue to OR, Y, BG and W had little effect and no selective action. The application of the results to color theory is discussed.

Troland (**155**) measured the differential threshold for brightness between all possible combinations of eight spectral colors (the so-called psychological primaries and their intermediates). The threshold increases to a maximum of from five to ten times that for zero color difference when the color difference is a maximum. The law connecting this relative increase with hue scale difference is the equation of the ellipse. Nagel (**109**) determined the brightness equivalence of red and gray. Within the limits of accuracy obtainable he found verification of Wirth's law of correspondence which declares that, if the equivalence value of one experiment is made the standard stimulus in a second series, then the second equivalence value will coincide with the original standard stimulus of the first experiment. The task of judging heterochromatic brightness equivalence requires observers trained to judge directly in terms of brightness as a relatively independent character. The task is not too difficult to admit of consistent results after practice. The papers of Harrison (**75**), Schjelderup (**141**) and Chaffee, Bovie and Hampson (**26**) have been reviewed above in connection with the discussions of Weber's Law.

Audition

A series of determinations of intensive RL's and DL's by physicists (largely from the laboratory of the American Telephone and Telegraph Co.) have appeared. While no standard psychophysical procedures were used in these studies and they are inadequate upon the side of psychological control of conditions, they are nevertheless of interest because of the apparatus used and the very accurate measurements of the physical intensity of the sound waves. With one exception (Lane) the source of the vibrations was a vacuum oscillator tube, whose frequency could be readily adjusted by varying the inductance and capacity of the actuating circuit. The intensity of the electric oscillations was controlled by some form of variable resistance, and the audible tone produced by either a telephone receiver or a thermophone. Kranz (**95**, **96**) determined

the RL for sound at six frequencies separated by octave intervals. He found large individual variations, and suggests a scale for measuring auditory sensitivity in units of energy required for the threshold. A further report (**97**) describes a somewhat different procedure for measuring sensitivity of the ear. In this experiment, the apparatus was set at a given intensity and the frequency varied by the observer, who found the range or ranges of frequency within which he could hear the given intensity. This procedure was repeated with increasing intensities. The curves obtained, although they showed variations between individuals and between ears of the same person, tended to show three regions of maximum sensitivity. Minton (**105**, **106**) investigated the RL of normal and abnormal ears. In middle ear deafness hearing is most deficient for low tones, while in inner ear deafness high tones are most affected. In true nerve deafness cases were studied in which a part of the tonal spectrum exhibited total deafness (tonal islands). Fletcher (**48**) measured the RL throughout the entire tonal range and found it to be low at the middle and high at the extremities of the scale. He also determined the RL for " feeling " the tones as pressures in the ears, which is practically the same as the RL for the tones as felt by the finger. Towards the extremes of the range, the threshold for " feeling " is lower than that for hearing. The upper and lower qualitative RL's are defined only by increase in the intensive RL at these points. A physical scale of sound intensities is suggested and applied to problems of telephonic communication and the measurement of deafness. Fletcher and Wegel (**49**) determined intensive DL's for normal and abnormal ears, using a very carefully controlled apparatus. Knudson (**92**) measured intensive DL's at eight different pitches and varying intensities with both pure and impure tones. His results follow the modification of the Weber-Fechner Law proposed by Nutting for visual sensations, with a " Fechner Ratio " (relative DL) of about 0.10. Guernsey (**68**, **69**) used the same type of apparatus to determine the RL at a number of pitches and then the successive DL's up to an intensity as loud as an ordinary speaking voice. Weber's Law appeared to hold with a fraction of about 1/3 in the middle range of intensities and frequencies, and with a somewhat larger fraction for very high, very low and very weak tones. Lane (**98**) reports measurements of intensive RL's for frequencies between 2,000 vbs. and the upper limit of hearing. He used a Hewlett tone generator placed outdoors at night as a source of sound. The limen is practically constant from 2,000 to 14,000 vbs.,

and then increases to a point between 18,000 and 20,000 vbs., where the tone becomes inaudible. Wegel (**159**) discusses the bearing of the physical determinations of the sensitivity of the ear upon the diagnosis of deafness.

Weiss (**160**) obtained tones of variable intensity by means of electrically driven forks placed at varying distances in front of resonators. He obtained intensive DL's at six frequencies. A theoretical explanation of intensity judgments in behavioristic terms is appended. Kiefer (**86**) reports experiments with the gravity phonometer, both monaural and binaural. With low intensities the monaural and binaural DL's are approximately equal; with high intensities the binaural limen is the smaller. The binaural RL, however, is always lower than the monaural threshold. The ratio of stimulus intensities, binaural and monaural, which gives subjectively equal sound is 1:2.46 for weak, and 1:5.49 for strong tones. The work of Geissler (**57**) and Travis (**154**) has been mentioned in another connection.

Heck (**79**) describes a mechanical flicker phonometer for comparing sounds by rapidly alternating them and varying the sounds until the pulsations disappear. MacKenzie (**103**) used an adaptation of this phonometer in which the alternation is electrical instead of mechanical, the tones being produced by vacuum tube, variable resistance and telephone receiver. With this apparatus he determined the relative sensitivity of the ear to sounds of different frequencies by a method analogous to flicker photometry. If two tones alternate at a suitable rate, the stronger tone is heard plainly interrupted, accompanied by the weaker tone whose interruptions are not clearly distinguished. If the relative intensities of the two tones are varied, a point may be found at which the two tones are equally interrupted. This point is identical with a loudness balance. A logarithmic relation was found to hold between pairs of frequencies at various intensities, in that the equated physical intensities, each substituted in the formula (with respect to constants, etc.) for its frequency, gave equal quantities. In other words, the relative intensities for equation of different frequencies showed a logarithmic relation to the absolute intensity of the standard stimulus.

Gilliland and Jensen (**64**) compare tests of pitch discrimination by means of Seashore's phonograph record with tests by means of tuning forks on the same subjects. While the record is standardized for practical test purposes, it is not satisfactory for laboratory experi-

ments. The investigation by Tittel (153) of the pitch DL has been mentioned in the discussion of the effects of special conditions.

Gleidemeister (64) measured the upper limit of hearing of persons of varying ages. He found it to decrease from about 20,000 vbs. in childhood to 13,000 vbs. in the late forties. Pratt (124) describes the use of steel cylinders for determinations of the upper RL for tones. Möller (107) used these cylinders to investigate the effect of intensity upon the threshold. The cylinders were actuated by steel balls dropped upon them from known heights. Psychometric functions are given for both frequency and intensity as variables, and limens in terms of frequency calculated by interpolation. There are differences between observers, but for a given observer the qualitative psychometric functions for different intensities are similar, as are the intensive functions for different pitches. No simple statement of the effect of intensity upon the upper limit seemed to be possible. Fletcher (48), however, found a definite relation, that the intensive threshold increases continuously as the pitch increases.

Rich (136) used a psychophysical procedure to study the theoretical problem of tonal attributes. The observers were instructed to judge, in different series, the vocality, pitch, volume, brightness and tonality of pure tones, and differential limens with respect to frequency were obtained under each instruction in three tonal ranges. Using inseparability and independent variability, as shown both by thresholds and by introspective reports, as criteria, three separate attributes are distinguished: pitch-brightness, volume and tonality. They are independently variable in that (1) their limens occur in the ascending order: pitch-brightness, tonality, volume; and that (2) the threshold for pitch-brightness decreases toward the center of the scale and increases beyond it, the limen for tonality increases steadily without following Weber's Law, and the threshold for volume follows Weber's Law. Halverson (70) found that the volume of a tone varies according to the relative phase of the tone at the two ears and measured the threshold for this variation. The volume is greatest when the phase-difference is zero or one-half the wave-length, and least when it is three-sixteenths of the wave-length, with three liminal steps between maximum and minimum. Halverson (71) also obtained differential limens for the volume of tones of constant pitch (from vacuum oscillator tube) as conditioned upon variations of the physical intensity of the sound. The volume of the tone varies in the same direction as the intensity, but the two are independently variable since the volumic limen is much larger than

the intensive limen. They may, therefore, be considered separate attributes. Weber's Law appears to hold for volume as a function of sound intensity as well as for volume as a function of frequency.

Pratt (**125**) studied the bisection of tonal intervals smaller than the octave by the method of equal sense distances, with procedure by the constant method. The point of subjective equality tends to fall near the geometrical mean. Owing to the equivocality of the judgments made on these intervals, it is not possible to give any adequate interpretation of the logarithmic relation which seems to hold between the stimulus and the mental process.

Taste

In the field of taste, psychophysical procedures have been used to obtain equivalent tastes, both liminal and supraliminal, in various attempts to investigate the chemical factors underlying the phenomena of sapidity. Gibson and Hartman (**61**) determined the RL's for three acids, using the constant method and Brown's procedure for application of the stimuli. The limens occur in the order of relative ionization, but are not proportional to it. Ostwald and Kuhn (**112**) report RL's for twelve acids obtained by Bohnen (**6**). They find that the taste of an acid varies inversely as its power to produce swelling of colloids, and give physico-chemical formulae for this characteristic. Paul (**113, 114**) measured the relative sapidity of supraliminal solutions of a number of acids by the method of equivalents with constant procedure. He finds that sapidity depends not only on H-ion concentration, but also on the capacity of the solution to yield its reserve of H-ions to the tongue and also to some extent on the nature of the anion and the vapor pressure of the acid. The sapid characteristic of an acid is called its molecular activity, and is given as a numerical value referred to the sapidity of HCl as a base. Pauli (**117**) used a similar experimental procedure to obtain the relative sapidity of sugar and saccharin. Renqvist (**134**) determined RL's for several homologous series of alcohols and esters. From a formula involving the diffusion coefficient, the adsorption exponent, the serial number of the compound and the liminal molar concentration for taste approximately constant values are obtained in homologous series. Komuro (**93**) measured the RL's for the four tastes at various temperatures. The limen decreases by about 50 per cent from 10° to 20° C. With further elevation of the temperature this effect is less marked, and the converse may even occur between 30° and 40°. Skramlik (**143**) produced tastes equivalent to those of

inorganic salts by mixtures of substances (NaCl, quinine, tartaric acid and glucose) and also determined several taste DL's. Fodor and Happisch (**50**) investigated the DL for solutions of NaCl and found that Putter's Law was a better statement of the results than Weber's Law.

Cutaneous and Kinaesthetic Sensations

Franz (**52**) determined the RL for pressure (stimulus-hair) on various regions of the body for normal and abnormal observers. He used a modification of the constant method, in which the value obtained was the percentage of responses for each intensity in a small area of constant size, and gives his results in the form of psychometric functions. Cerebral and some spinal hypaesthesias show increase in the thresholds for all parts of the skin, while other spinal and all peripheral diseases of the pressure sense show some regions in which the limen is normal or about normal, but even in them the stimulus required to obtain 100 per cent judgments is increased. Halpern (**72**) produced an artificial hyperaemia of the skin by means of either mercury vapor, mustard plaster, acetic acid or potassium hydroxide. The effect of the hyperaemia upon the threshold for stimulation by a hair is first a decrease in sensitivity, followed by an increase.

Hansen (**74**) determined DL's for intensity of pressure, working with stimuli of various extents from a point up. For point stimulation the relative DL is about 40 per cent, for larger areas it is only 10 to 20 per cent. It is largest of all when an isolated pressure spot is stimulated. He concludes that Weber's Law, in so far as it possesses any validity for pressure sensations, is conditioned by extensive rather than intensive changes of the stimulus. The experiments of Borak (**8**), Kiesow (**87**) and Gatti (**56**, **88**) have been reviewed earlier in this paper.

Bush and Austin (**25**) measured DL's for pressure on the hand and for tension (lifting from the wrist) with continuously variable stimuli produced by allowing water to flow into a beaker. The results have already been mentioned in the section on the effects of special conditions. Ortmann (**111**) determined the DL for pressure on levers similar to piano keys and correlated the results with his observers' technical pianistic skill. The correlations obtained are positive but low, the more talented performers tending to have the smaller limens. Percussive touch yielded coarser discrimination than did nonpercussive touch. Larger thresholds were obtained when

the hand, forearm or arm moved than when the movement was of a finger only. Movements of the key both up and down gave the smallest limens, movements down only those next in magnitude, and movements up only the largest thresholds.

Putter (**130**) determined the DL for temperature. It was never less than 0.5° C. and was smallest in the region of 28°, rapidly increasing in either direction. Weber's Law was found not to hold for either warmth or cold, but a new law that the threshold is an exponential function of the stimulus. Gertz (**60**) investigated the effect of adaptation upon the DL for temperature and found that the limen is less the nearer the standard stimulus is to the temperature to which the skin is adapted.

Fernberger (**42**) describes a cylinder for use in lifted weight experiments which has the advantages of uniformity in size and in apparent temperature and of invariability under changes in humidity. The experiments of Friedlander (**53**), Fernberger (**40, 41, 44**) and Reid (**133**) involved the use of lifted weights, but these studies are concerned with the effects of particular conditions upon the psychophysical judgment and were considered in detail under that head.

Perception

Koruda (**94**) determined the least discriminable distance between two seen points (space threshold), and found it to be the same whether one or both eyes are used. Binnefeld (**4**) used both lines and distances between points to determine the DL for visual length. In the light, the average relative DL is 1/40. Working in the dark with distances between points, it is slightly higher. Tachistoscopic exposures were also used to rule out eye movements, with little effect. Herrmann (**80**) and Geissler (**57**) used the comparison of visual extents to study the effects of background and expectation, respectively, as already mentioned. Lips (**101**) compared two simultaneously presented vertical lines with a third line which appeared in between in the space just occupied by the first two, using the constant method. The double judgment gives a greater scatter than does the single judgment, but a smaller interval of uncertainty. This result is probably due to the stimulation afforded by a more complex task, yet one which can be attended to in a unitary way. Wolfe (**163**) studied the estimation of the middle of lines (strips of white paper). He used the method of average error, the observer making a pinhole at the apparent middle. The experimentation was both extensive (400 untrained observers) and intensive (2 trained observers). The aver-

age error was found to be about 1 per cent of the entire length, and to become reduced by practice. Weber's Law seemed to be valid within the range used (50–1,000 mm.).

Anderson and Weymouth (1) used white threads on a black surface to investigate DL of binocular perception of distance. With the threads 4 cm. apart and 2 m. from the observer, the limen was 70 mm. They attempt to explain the fact that the threshold is less than the diameter of a retinal element by a theory of retinal mean local sign. Bates (3) utilized a psychophysical procedure to study the Müller-Lyer illusion. The stimuli were lines or dots presented either successively or simultaneously, with and without wings of varying brightness and under varying instructions. The constant method was used and the results are presented both as psychometric functions and as calculated points of subjective equality. The numerical results indicate the possibility of objectively measuring attitudinal change. In this case, the effect of shift of instructions is statable in terms of the amount of change in wing-brightness necessary to change the illusion by the same amount.

De Miffonis (33) determined the average error of placing a light vertically under a second light. With the two lights separated by a visual angle of 0° 22′, the error of verticality is less than 1′. Tinker's (151) experiment in adjusting a line to a number of points, already mentioned, might be considered a study in space perception. Rubin (139) investigated the problem of straightness. Two lines must diverge 30″ to be seen apart, but lines to be seen as straight must not diverge more than 22″. Attitudes have a direct effect upon the limen for curvature as determined by the method of limits. In the constant method, these attitudes are replaced by tendencies to bend the line to right or left and by direction of attention. The constant method yields the smaller limens. Gellhorn (59) had his observers compare the separation of an aesthesiometer, placed on thumb and forefinger (blindfold) and separated in this position to a given distance, with the aesthesiometer set to a given distance and shown visually (method of equivalents). Rapidity of movement in separating the points on the skin turned out to be the important factor in this comparison of visual and cutaneous extents.

Stewart and Hovda (147) studied the effect of intensity upon localization of sounds by conducting sounds of equal phase but different intensities to the two ears. They found that the amount of angular displacement is proportional to the logarithm of the ratio of sound intensities, and considered this relation an extension of

Weber's Law. When Stewart (**145, 146**) later verified this law, he came to the conclusion that it is a new law rather than an extension of Weber's Law, because it is concerned with the recognition of differences in nervous response, while Weber's Law is a law of nervous response.

Goudge (**65**) explored 42 regions of the body for Weber's Illusion. In the quantitative experiments five positions were chosen on each region studied. The points of an aesthesiometer were then set at a standard separation for the first position and the equivalent separation at the second position determined. Starting with this magnitude, the equivalent separations at the other positions were found. These quantitative determinations by the method of equivalents were made on five parts of the body (only qualitative results being obtained from the other regions explored). Kincaid (**89**) obtained experimental data to show the paradoxical error of reporting a dual impression for a single-point stimulation of the skin (in experiments upon the limen of dual impression on the skin). Assuming that this error indicates two antagonistic dispositions, one to judge "two" as the separation increases, the other to judge "two" as the separation decreases, she attempted to express the psychometric function as a combination of two functions corresponding to the two dispositions. Friedline (**54**) worked with two-point stimuli separated by less than the threshold of dual impression and required her observers to differentiate between various degrees of separation. They either were able to distinguish between the various cutaneous patterns with a high degree of correctness or else failed completely to do so. When fatigue was present, it was not possible to maintain a constant attitude toward the different patterns. This fact explains the effect of fatigue upon the two-point limen as usually found. Fatigue does not change the real threshold, but the criterion of the observer changes from some pattern which is subliminal, but distinguishable from a single point, to the true two-point criterion. Boring (**19**) discusses the bearing of experiments on the two-point limen in areas recovering from nerve division upon Head's theory of cutaneous sensibility. Pieron (**119**) investigated the two-point threshold for temperature sensations. His method consisted of dropping two drops of water upon the skin from an aesthesiometer. He believed that he obtained in this way a temperature sensation free from pressure, although experimenters who tried the same method for the localization of a single temperature sensation found that it did not give the desired results. Thresholds were obtained for temperatures from

32° below skin temperature to 21° above it. The limen was smallest at the extremes and largest at skin temperature.

Hoisington (81) used psychophysical methods to study the perception of the length of lifted rods. While his main task was a qualitative analysis of the perception, he obtained psychometric functions for differences in apparent length as conditioned upon the length, weight and center of mass of the rod. Limens were not computed because the perceived length depended upon the ratio between two opposing pressures in the hand, but there was in the stimulus-object no directly comparable element or moment which could be utilized as a base for computation. Shults (142) extended the work of Hoisington to the perception of rods whipped vertically. Limens were computed from the raw data, but only in terms of arbitrary units not corresponding to physical units of the stimulus. Baker (2) made a similar study of horizontally whipped rods.

Pirig (122) investigated the relation between perception of position by the arm and by the eye. He determined the DL for position of the arm by means of the Störring kinematometer and found it to be 0.64°, while the DL for position of the eye, obtained by the fixation of points of light in a dark room, was found to be 0.27°. The study by Garrison (55) of the thresholds for arm movement has been dealt with in connection with the effect of attitude upon the psychophysical judgment.

Klemm (90) measured the binaural temporal limen, that is, the threshold for the temporal succession of two sounds led to separate ears, such that they shall be separately localized. For one observer a threshold as low as 0.01° was found.

Attention

Fernberger (43) examined the classical experiments upon the so-called range of attention and found that the concepts employed were neither clear nor exact. Sometimes 100 per cent of correct judgments was used as the measure of discrimination, while at other times this percentage was not reached experimentally. The available data suggested that the statistical limen would form a more reliable and more readily determined measure of the range of attention. In a preliminary experiment, sets of from 4 to 12 dots were exposed tachistoscopically and the percentage of correct responses determined. The psychometric functions obtained are presented together with the limens computed from them. The latter vary between 6 and 11 dots, according to the observer and the conditions of presentation. Intro-

spective reports indicate that the determination was one of range of visual apprehension rather than of range of attention. Oberly (**110**) continued this work in a more extensive study. On the basis of preliminary reports, three types of conscious situation were distinguished and the observers instructed to report in terms of them. The first type was an immediate report in which all sensory elements were equally clear, and the thresholds of correct response for reports of this type were called limens of range of attention. The second type of conscious pattern involved the grouping of elements on different levels of clearness. Thresholds for cognition included correct responses of either of these two types. The most complex method of response involved counting, with the use of some mediate process. Limens for visual apprehension were computed from the percentages of correct responses of all forms. In all cases, judgments lacking in certainty were eliminated. As is inherent in the method, the thresholds are greatest for apprehension and least for attention, with cognition intermediate. Practice tends to increase the value of the limen, especially for attention.

Bowman (**21**) used the method of limits to ascertain the illumination necessary to make a cross of given size equally clear, on tachistoscopic exposure, with a larger or smaller cross. Size as a determinant of attention was found to bear to intensity a ratio of from 3:1 to 4:1. Spatial position proved to be a major disturbing factor, the left-hand position having the attentional advantage. Dewey and Dallenbach (**34**) made similar observations, using spots of light instead of crosses and proceeding by the constant method instead of the method of limits, but obtained similar results. Dallenbach (**31**) followed up the factor of position. He used the constant method to determine the relative intensity of two lights in various spatial relationships to each other such as to give equal clearness. The left-hand position has the attentional advantage. Burke and Dallenbach (**24**) repeated this experiment with left-handed observers and found that for them the positions to the right instead of those to the left have the attentional advantage.

Association

Williams (**162**), working under the direction of Boring (**9**), attempted to apply psychophysical procedure to the measurement of association. The similarity of the problems of measurement in sensation and in memory suggests the determination of a "mnemometric function," comparable to the psychometric function, and the calcula-

tion of an associative limen as a measure of memory. The concept of a threshold is valuable in this connection, as a given reproductive tendency can only be determined to be either adequate or inadequate to reproduction, just as a given stimulus can either produce or fail to produce a sensation. Using an adaptation of the constant method, the percentages of correct response for five numbers of repetitions were obtained, all other factors being held constant. The "mnemometric functions" secured show inversions and do not directly fit the *phi-gamma* hypothesis. On the supposition that repetitions are progressively less effective and are, therefore, not mnemonic units, the values of the numbers of repetitions were expressed as logarithms, square-roots, cube-roots and hundredth-roots, and the *phi-gamma* hypothesis applied to the transformed functions. The logarithmic transformation gives the best approximation to the theoretical curve, as well as the smallest liminal values. The same mathematical procedure was applied to the data from a number of classical experiments in memory, with like results. Ernst, Smith, Moessner, Rudisill and Atwater (39) extended this type of study. They determined the strength of the associative tendency, as measured by the constant procedure applied to the method of right associates, for five numbers of repetitions with a constant rate of presentation and for five rates of presentation with a constant number of repetitions. The data are first presented in the form of "mnemometric functions." A number of mathematical hypotheses were then tried out as means of computing associative limens from the crude data, and the adequacy of each hypothesis tested by Thomson's criterion. It was found that, of the hypotheses tried, a combination of *phi-gamma* and square-root hypotheses was most adequate to the "mnemometric functions" for variable number of repetitions, and the *phi-gamma* hypothesis applied to time per unit read most adequate to the functions in which rate of presentation was the variable.

Other Applications

A few workers in the field of psychophysics have applied their results to practical situations, although but a start has been made in this direction. DeMiffonis (33) determined the average error of placing one light vertically below another, and applies the result to the task of a pilot following a channel by keeping two lights (one placed higher than the other) in a vertical line. From his figures for the average error, he calculates the necessary vertical separation of a

pair of lights as conditioned upon the distance of the lights from the boat and the width of the channel to be followed.

Hazelhoff and Wiersma (**77**) apply liminal determinations to the problem of right- and left-handedness. Their experiments with liminal faradization, with discrimination of light weights, and with the aesthesiometer show that, in right-handed persons, the left hand is the more sensitive, with opposite results for a single left-handed observer. The theory is suggested that the development of motor functions in the hand most used inhibits its sensitivity. In their measurement of conditions of attention already quoted, Burke and Dallenbach (**24**) find a difference in attentional preference between right- and left-handed observers.

On the side of clinical applications, Franz (**52**) found that the RL for pressure could be used in differentiating between types of hypaesthesias, as has already been mentioned. Minton (**105**, **106**) observed that in middle ear deafness low tones are most affected, while in inner ear deafness the hearing is most deficient for high tones, and that in some forms of true nerve deafness tonal islands appear. Fletcher and Wegel (**49**) obtained sensitivity curves for abnormal ears. Fletcher (**48**) proposes a physical scale for the measurement of deafness in terms of the intensive RL. Wegel (**159**) discusses the value of determinations of the sensitivity of the ear for the diagnosis of deafness. Cobb (**28**) describes the use of threshold measurements in examinations for Air Service.

Three papers have appeared in which psychophysical principles are applied to reflexes. Engelking (**38**) determined the minimum brightness necessary to produce a pupillary reaction, using both photographic and entoptic methods of observation. Under dark adaptation, the threshold for a positive response is .025–.04 meter-candle, although the first intimation of a response same at only .001 meter-candle. These facts lead to the conclusion that a slight pupillary reaction is aroused by stimulation of the rods of the retina, but that the function depends mainly upon stimulation of the cones. Groethuysen (**67**) used the Hess pupilloscope to measure the pupillomotor DL for brightness, and found it to be identical with the optical DL. It is not influenced by diseases of the retina, optic nerve, etc. Radovici and Fischgold (**131**) recorded the reflex contractions caused by induced shocks applied at varying rates to the skin in cases of paraplegia. The rate of response varied with the rate of stimulation and the relation between these two variables was similar to Weber's relation between excitation and sensation.

Lyon (102) contributes a pharmacological application. He measured the effects of various amounts of adrenalin (intravenous injection in cats) upon blood pressure. The relation of the pressor effect to the amount of adrenalin administered follows the Weber-Fechner Law, and Lyon was able to work out the constants of Fechner's formula for this reaction.

Kelley (84, p. 329) suggests the use of psychophysical methods in the educational field and gives an example of how the constant process may be used in ranking English compositions on a scale of merit.

Kniep (91) discusses the psychophysical analogies that may be found in botany. He shows that a number of psychophysical concepts and laws are valid in the case of plants. Some of these are the concept of the RL as applied to tropisms and other phenomena of stimulation, the hyperbolic law of the relation of intensity of stimulation to length of stimulation such that the product is constant, Talbot's Law and the Weber-Fechner Law, which was first shown to be applicable in the botanical field in the case of bacteria. Stark (144) investigated the differential sensitivity of plants, including bacteria, using a number of methods of procedure. The thresholds are very large as compared with those of psychophysics. Thus, the DL for chemotaxis ranges from 0.03 to 400 times the standard stimulus, and that for contact stimulation from 2 to 3 times the standard. Weber's Law holds for chemotropisms, haptotropisms, chemotaxis, and to some extent for geotropisms. It can not be proven in the case of phototaxis. Rippel (138) found that the Weber-Fechner law holds for the responses of plants to various chemicals. He suggests that it is a general law of response, widely applicable in the organic world.

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PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING OF THE SOUTHERN SOCIETY FOR PHILOSOPHY AND PSYCHOLOGY, CHAPEL HILL, N. C., APRIL 13 AND 14, 1925.

REPORT OF THE SECRETARY-TREASURER, J. A. HIGHSMITH, NORTH CAROLINA COLLEGE FOR WOMEN, GREENSBORO, N. C.

Meeting of the Council of the Southern Society for Philosophy and Psychology in Phillips Hall, April 13, 5 P.M. Present: J. F. Dashiell, President; A. S. Edwards, Buford Johnson, Herbert Sanborn, J. B. Miner, and Knight Dunlap (acting Secretary in the absence of Mr. Hughes).

The following recommendations to the Society were made:

(1) For officers for the year 1925–26: President, J. B. Miner; Vice-President, Josiah Morse; Secretary-Treasurer, J. A. Highsmith (3 years); Members of the Council, A. S. Edwards, J. F. Dashiell, and W. O. Furry.

(2) That the invitation for the Society to meet at the University of Kentucky next year be accepted; and that the invitation from the University of Georgia for the year following be accepted.

(3) That the meetings of the Society be held on Friday and Saturday before Easter, subject to change by the Council in case the need for change arise.

(4) That seventeen nominations for membership be approved and ordered reported to the business meeting of the Society.

Business Meeting, 9 A.M., April 14, President Dashiell in chair.

(1) On nomination by the Council the following officers elected for the next year: President, J. B. Miner; Vice-President, Josiah Morse; Secretary-Treasurer, J. A. Highsmith (for 3 years); Members of the Council, A. S. Edwards, J. F. Dashiell, and W. O. Furry.

(2) Seventeen nominations for membership were made by the Council and were elected by the Society to membership.

(3) The recommendation of the Council that the invitations for the Society to meet at the University of Kentucky in 1926, and at the University of Georgia in 1927, was approved.

(4) The proposal to change the time of meeting to Friday and Saturday before Easter was approved, subject to action by the Council.

(5) Dr. Dunlap offered a resolution proposing an amendment to the Constitution of the Society abolishing the office of Vice-President. The resolution was adopted, the final vote to be taken in the session of 1926.

(6) A resolution was proposed by Dr. Miner extending the thanks of the Society to the University of North Carolina for the cordial hospitality shown to the Society and was unanimously adopted by the Society.

ABSTRACTS OF PAPERS

Investigation of Child Welfare in the Institute of Social Research at the University of North Carolina. A. M. JORDAN, University of North Carolina.

The Department of Educational Psychology of the University of North Carolina participates in the recent gift of the Laura Spelman Rockefeller Foundation to the extent of one assistant and ample funds for the carrying out of any reasonable research problems. The problem chosen is concerned with the consecutive mental measurement of children whose parents work in cotton mills. Standardized group tests are being used with the intent of checking up on any unusual cases with the Stanford-Binet. The work is to last over a period of three years and some emphasis will be placed upon physical as well as mental growth.

The Function of Philosophy in Liberal Education. HERBERT SANBORN, Vanderbilt University.

As a natural result of our pioneer environment and traditional orientation we have come in America to make a fetich of *abstract* practicality to an extent that is provincial in comparison with other civilized countries. However justifiable this may seem to have been in the past, it is evident that we have now arrived at a period of world-development, when this attitude is or soon will be detrimental in the highest degree. Under the influence of this national obsession, we have passed from a personalistic, aesthetic, concrete sort of education to one which overstresses work in impersonalistic, abstract subjects. In providing for justifiable differentiation in education we are overlooking the equally important function of integration and are not furnishing adequate education for leadership in political and social life. Liberal leadership doubtless rests on liberal education that frees the individual from bondage and prejudices of various

kinds, developing in him the capacity for putting himself in the place of opponents and of appreciating things from more than one point of view. Such development, however, is hardly possible under a system which allows the average student only one ultimate point of view—that of atheistic naturalism, based upon a probably fallacious interpretation of scientific results.

Under the domination of his environment and traditional orientation the election of the immature student can hardly be said to be free; and while as a matter of mere theory all subjects are doubtless equally liberal, in actual practise some of them tend more readily than others to become *abstractly* vocational in spirit. If academic freedom means the right to pursue and to communicate the concrete truth, then the present compartmental curriculum, under the influences referred to, amounts to an infringement of academic freedom; its aim is not truth in its integrity; so that even when threatened with the disaster of unenlightened political restriction it has greatly weakened its defense based on its natural claim to academic freedom. This is probably the situation whenever a scientist passes beyond the field in which he is competent into the philosophic field, and is teaching atheistic naturalism.

The importance of historical, philosophical, humanistic education has become clearer through the realization (based on the epoch-making work of Groce and Rickert) of the nature of history and of its intimate relationship or identity with philosophy. Science needs to be humanized, not in the sense that it shall be merely popularized "in pulpit and magazine science", but in the sense that its function in truly *intelligible,* human life shall be evident. The function of philosophy should be the accomplishment of a unification of the college curriculum, and this subject should be prescribed for every candidate for a bachelor's degree.

The organization of the liberal arts curriculum should center about the social sciences; and these should be oriented, not merely with respect to an abstract sociology, but chiefly with respect to a social philosophy, even international in scope. For the purpose of such humanistic organization, which will demand a first-hand acquaintance with foreign languages and literature, some curtailment of English and history courses would seem to be indicated—novel reading, sectional and national literature and history—it being, from the point of view of education, more important for a student to be familiar with the great epochs of history and the masterpieces of the world's literature. Thus time might be saved for more serious

work in both science and humanism that needs the direction of an instructor. Specialization should be relegated largely to institutions especially fitted for such work, but even in such institutions provision should be made for a philosophical orientation for all scientific and humanistic students; since leadership, even in special fields, is conditioned by a broader view than is provided for by training adequate for mere coöperation in special investigations.

Controlled Word Associations to Verbs and Adverbs. KNIGHT DUNLAP and A. L. FINESINGER, Johns Hopkins University.

A new method of studying controlled word associations has been developed and applied to number adding and number subtracting, to adjective-noun and noun-adjective reactions, and to adverb-verb and verb-adverb reactions. The significant result is that the adverb-verb reaction is shorter, in general, than the verb-adverb reaction, in spite of the more usual order of speech being verb-adverb. Doubt is thereby thrown on Loring's explanation of the shorter adjective-noun reaction, as compared with the noun-adjective reaction as due to the normal adjective-noun order of English speech.

Psychological Problems of Population. KNIGHT DUNLAP, Johns Hopkins University.

The important psychological problems of population include the following: (1) The problem of race psychology, as yet a merely theoretical subject. The prospect of obtaining psychological data concerning racial differences is dubious, and is distinctly negative as regards savage races. (2) The problem of eugenics. Eugenic possibilities are practically limited to the negative program, for which contraception alone offers a possible means. (3) The problem of overpopulation. This is essentially connected with the problem of war, which is one of the most pressing of present psychological problems.

The Effects of Suggestion and Tobacco Smoking on Pulse Rate and Blood Pressure. ROY M. DORCAS, Johns Hopkins University.

The problem under investigation is whether the rise in blood pressure and pulse rate which accompanies cigarette smoking is due primarily to physiological causes or whether it is due to psychological causes. The method of attack differed from the usual methods in that hypnosis was employed in conjunction with other "control" measures for deceiving the reactors. The conclusions were that the

increase in blood pressure and pulse rate which is produced by smoking is caused by physiological conditions rather than by psychical conditions. Another interesting finding was that there is an increase in the intensity of the heart beat when tobacco is smoked.

Limits of Trial and Error Learning. JOSEPH PETERSON, George Peabody College.

The kind of learning that we call trial and error seems to be that which has so-called useless or random movements, or "errors". These errors become gradually eliminated as learning progresses. It has been suggested that learning may be nothing more than the dropping off or elimination of these "superfluous" movements. Some writers seem to regard learning which does not display such useless movements as qualitatively different from learning by trial and error. The present experiment was devised to study the alleged difference between such forms of learning. The letters of the alphabet arranged in a key in their regular order were numbered in a random order from 11 to 36, so that the position of any given number had to be learned. E, by means of an electric key and time marker, was able to indicate on a kymograph record over a one-fifth second's scale simultaneously made by a Jacquet chronometer, the instant when he called out any number and also the time relatively of S's response with the corresponding letter. S was permitted to keep the key before him, and was asked to respond to successive numbers with their respective letters as quickly as possible; but he was told not to respond in any case until he had definitely located the letter of the number given. An error was then defined as a failure to make response within a predetermined period of time, as two seconds or one and one-half seconds. The error curve of learning thus obtained did not differ significantly from the usual error curve found in learning experiments. But is is interesting to note that when the errors had been eliminated for any one of the chance orders of the stimulus series, a more rigid criterion (*i.e.*, the use of a more restricted time period) again revealed them. Observation of S's responses showed frequent eye movements and irregularities in responses, and S's verbal report revealed corresponding "inner" or implicit "superfluous" processes, which did not differ in essential details from explicit trial and error movements. These were found to persist, but to become more and more refined in their nature and harder to detect, as the learning became more and more advanced; but finer and more rigid criteria revealed them as long as learning

continued. It may be doubted whether any learning will not be found by sufficiently delicate methods to consist essentially of the trial and error form. The idea of gradual perfection through invariable repetition of acts may have little real foundation.

A Group Color-Blind Test and Some Results. JOSEPH PETERSON, George Peabody College.

A short demonstration of a group test taking but fifteen or twenty minutes and the indication of some desired changes in it. The test is nonlinguistic and does not depend on the subject's knowledge of colors. Its possibilities of exhibiting the reactions of color-blind individuals are illustrated.

The Space Order Reaction of Young Children. SCHACHNE ISAACS, Johns Hopkins University.

Two sets of sixteen colored pictures, of varying degrees of interest, familiarity, and attractiveness, were mounted in rows of four on charts, 20 x 20 inches, ruled off in 5-inch squares. These were presented to the child who was given a yard stick and asked to point to and name as quickly as he could all the pictures on the chart. The examiner recorded on a prepared form the order of naming, noting repetitions and omissions. Fifty kindergarten children, and 21 pupils in Grade 1-B who had had some months of blackboard reading, were given the test. A second test was given to other similar groups, and to a group of 18 pupils in Grade 1-A, in which the child was asked to put a check in each circle of a set of 16 half-inch circles, ½-inch apart, in rows of four. A similar record of order of checking, repetitions and omissions, was made.

The most effective response to these requirements, for speed and the avoidance of repetitions and omissions, is, of course, to begin in one of the four corners and name or check across rows or up and down columns. A number of adults tested, gave, without exception, the reading order of response. The question arises, at what age does an "orderly" response appear, and what is its relation to the reading habit of beginning in the upper left hand corner and moving from left to right in the lines and right to left from line to line?

Of the 50 kindergarten children, in the first set of pictures, 6 gave an orderly response, and of these, 5 the reading order; in the second set, 18 gave an orderly response, and of these, 12 the reading order. Of the 21 Grade 1-B pupils, in the first set of pictures, 9 gave an orderly response, and of these, 8 the reading response;

in the second set, 12 gave an orderly response, all of them in the reading order. In the checking test, of the 49 kindergarten children, 13 gave an orderly response, of these, 6 the reading response; of the 28 Grade 1-B pupils, 18 gave an orderly response, of these, 12 the reading response; of the 18 Grade 1-A pupils, 13 gave an orderly response, of these, 11 the reading response. The indications are that the systematic space order reaction is determined by training in reading.

Blonde and Brunette Characteristics. A Study in Character Analysis. JOHN E. WINTER.

Popular books on business efficiency usually lay claim to a sound psychological foundation. Character analysis as an essential to successful business relations assumes an important place among the topics discussed, and authors generally resort to some modified form of phrenology or physiognomy for a psychological foundation. Among the criteria for the determination of character is that of color of skin, hair and eyes.

Blackford and Newcomb in their book "The Job, the Man and the Boss" lay down the rigid principle that the more an individual approaches a pure blonde or pure brunette the more will he manifest certain definite traits of character. To test the validity of these statements the following experiment was undertaken.

Twenty-nine judges were chosen, nine of whom were women. Each judge chose two blondes and two brunettes from among his intimate acquaintances, making a total of one hundred and sixteen subjects. The judges were given lists of blonde and brunette characteristics arranged promiscuously so as to avoid any suggestion as to what particular traits were supposed to belong to blondes or brunettes. Each subject received a positive or negative mark opposite each trait, indicating the presence or absence of that particular trait in his character.

The results were plotted in a series of graphs, and various correlations were worked out. It was found that in general a high percentage of blondes possessing blonde traits was accompanied by a comparatively high percentage of brunettes possessing the same trait. This held good for the brunette traits also. The results of the experiment were thus decidedly at variance with the theory of Blackford and Newcomb.

The conclusions arrived at were as follows:

1. The experiment reveals no plausible ground for Blackford

and Newcomb's theory of the relation between color and character traits.

2. Sex differences among the subjects play a larger rôle than color differences in the determining of character traits.

3. Sex differences among the judges appeared in the particular traits stressed.

The Effect of Music Upon the Ability to Coördinate. E. W. ATKINS, University of North Carolina.

This report deals with a study of the coördination scores of 60 students. These students were given the Dunlap form of the Johns Hopkins Coördination Test twice—once while they were keeping time to late dance records and about three months later when the same records had become very familiar to them. In addition a comparison was made with a metronome operated at the same rate as the music. The scores on the Coördination Test with music were somewhat better than those without the music, but this difference seems to disappear with increasing familiarity of the music.

Intelligence Tests and Scholastic Ratings. A. S. EDWARDS, University of Georgia.

On his return from the army in 1919 the writer tested all students of the University of Georgia who reported for the examination and since that time has studied the scholastic ratings of these students. Both sets of records, Alpha and scholastic were had for 432 students. For all students the Pearson coefficient was .352, P. E. .0283. The highest correlation was for Freshmen, 169 cases, namely, .456, P. E. .0408. The median Alpha standing for all students was 123.3; the median scholastic standing according to the registrar's books 76.9. A student rating A or B on the Alpha examination may rate from A to failure in scholastic standing; a student who rates C plus or C on Alpha cannot expect to get a scholastic rating of A, but here prediction halts, for he may get any other scholastc standing. Another study was made in connection with the city school children, the Haggerty Delta 2 being used for grades 3 through 7; and the Otis Advanced test being used for the High School students. Here we combined the teachers' judgments with the results of the psychological examinations and thus made predictions which during the following five years have proved to be of a very high degree of accuracy and of administrative value. From these studies it may be said that the intelligence test was of practically no predictive

value for individuals, although it gave valuable supplementary information, and that the intelligence test plus teacher's judgments gave information of very high administrative value.

Significance of Intelligence Tests of College Students. BUFORD JOHNSON, Johns Hopkins University.

Intelligence tests have not been used in many colleges as an entrance requirement, but have been widely used for the prediction of success in college work as an aid in elimination and guidance of students. The primary method of evaluation of the tests has been the correlation of the scores with college grades. The coefficients of correlation obtained have varied widely even for the same form of intelligence test and no high coefficient has been reported. Assuming that success in college work is determined by past educational training, personality traits, and mental capacity, the question is asked if a high coefficient of correlation between intelligence tests and college grades is desirable. To what extent each of the three factors mentioned conditions the results of the intelligence tests is not known. The validity of college grades as measures of college work is not established.

There is need of analysis of individual responses to items in sub-tests forming the battery used as an intelligence test toward the end of constructing batteries of tests more reliable for differentiating the abilities of college students. Means of measuring the educational achievements in High School should also be obtained. These measurements should be combined with a psychological analysis of the problems and activities of the individual student.

A Method for Evaluating an Interest Psychograph for Vocational Guidance. J. B. MINER, University of Kentucky.

A method for evaluating records of interests was developed and illustrated in connection with the writer's paired interest contrasts used on his blank for the analysis of work interests. The method involves the comparison of groups in different occupations with a random group. Pseudo-professional groups among college freshmen at the University of Kentucky aiming at engineering, law, medicine and teaching were used for illustration. After stating the value of each check mark in sigma for the random group on the assumption of normal distribution of the interest, the value of the same mark in each professional group is determined by the percentage departing from the common choice. This permits the record of a

person to be rated for each profession and the totals compared. When the results of the method were tested for 20 students in each vocational group, the success of the method was at least three out of a possible four times what chance would give. At least 65 per cent were properly placed. To these should be added those who were working toward a profession which might be less satisfying because their interests were more in line with those in another group. The method would be useful for evaluating any profile of traits in relation to typical groups when the degrees of a trait cannot be scored in small units.

Organization and Work of the Bureau of Mental Hygiene of the North Carolina State Board of Charities and Public Welfare. H. W. CRANE, University of North Carolina.

HERRING, J. P., *Herring Revision of the Binet-Simon Tests, and Verbal and Abstract Elements in Intelligence Examinations.* Yonkers: World Book Co., 1924. Pp. 71.

The first part of this little book contains the data on the derivation and validity of the Herring Revision of the Binet-Simon tests. Some of this material has appeared in the *Journal of Educational Psychology,* March, 1924. As one of the purposes of Dr. Herring's investigation was to build a new series of individual intelligence tests which assume our present criteria and correlate with them as highly as possible, the standard of reliability is the correlation with the Stanford-Binet test. This is, under favorable conditions, as high as $+.9908 \pm .001$ with a probable error of estimate of 2.37 points in I. Q.

In the second part of the book Dr. Herring examines the objections made to the Stanford and similar series purporting to measure general intelligence, namely that they are composed too exclusively of verbal and nonconcrete matter. The statistical procedure consisted of setting up on the one hand a "weighted composite criterion" of intelligence composed of the following:

	Weights
1. Stanford Binet	3
2. Educational age	3
3. Relation between CA and the grade reached at the time of the study	3
4. National Intelligence Test	2
5. Teachers' estimates of intelligence	1
6. Thorndike paragraph reading examination Alpha 2	2
7. Kelley-Trabue Completion Alpha	1

On the other hand were two scales, one (C) ranging from very concrete to very abstract, the other (N) ranging from very nonverbal to very verbal. The units for these scales C and N were selected from the following tests:

Dearborn Group Intelligence Examinations
Army Beta Examination
Indiana Mental Survey Primer Scale
Indiana Cross-out Tests
Thorndike Visual Vocabulary

The units were classified as belonging to either C or N by five competent judges. On the whole the correlations with intelligence, as defined by the criterion set up, were higher for abstract than for concrete tests, and higher for verbal than for nonverbal tests. Whether one accepts the resulting interpretation for pure psychology and for society at large depends upon the reliance one places upon their *a priori* plausibility and upon the assumed "weighted composite criterion" of intelligence.

LORLE I. STECHER

State University of Iowa

MACPHAIL, A. H., *The Intelligence of College Students,* Baltimore: 1924, Warwick and York. Pp. viii + 176.

The increased demand for admission into existing colleges with limited equipment has in many institutions called for a restriction of the number of students admitted. Restriction in numbers has brought with it the need of selecting from prospective applicants those best fitted by nature and training for what the college has to offer.

The first part of "Intelligence of College Students" is devoted to a survey of current practices in methods of admission to colleges and universities with special reference to the use of intelligence examinations, which have assumed a very prominent place in connection with college entrance. From numerous thorough investigations made to determine objectively the relative value of the various college entrance criteria, the order of validity from the most valid to the least valid seems to be (1) intelligence examination, (2) high school record (certification), (3) comprehensive examination, and (4) content examination (old type). Although the intelligence examination appears to be the best *single* criterion for admission, it is not sufficiently accurate to be used as the *sole* criterion. Coupled with others, particularly with high school record (certification), it affords a far better set of prognostic criteria than has heretofore been available.

Intelligence examinations have been used with satisfactory

results in many colleges not only in the selection, but also in the classification of students for the purposes of instruction; in making decisions on whether or not a student who asks permission to carry more than the usual amount of work should be permitted to do so; in choosing scholarship men; in probations; in determining the causes of failure; in dismissals from college, and in recommending students for positions. The author aptly points out that the institution that concentrates its energies to a superlative degree on its selection of freshmen and stops there, can claim for itself but little of the glory achieved by those admitted and graduated. It is also its function to keep a student in college once he is admitted; to help him make the most of himself and his opportunities while he is in college; to aid him in the choice of a profession after graduation. Those are the aims of the guidance movement. The educational guidance program so far as it concerns higher education should have its beginning in the high school, in guiding into college individuals of merit and away from college into other pursuits those whose incapacity is sufficiently obvious, and should find its culmination in the scientific application of the criteria discussed above, particularly intelligence examinations, in the study and treatment of the individual college student.

In Part II of the book is presented a very complete and careful analysis of the various criteria of admission and retention at Brown University. The relation of psychological tests to academic achievement, to separations from college, to the achievement of academic honors, and to the pledging and membership in fraternities are subject to detailed examination and interpretation. In addition the principal's estimates and rank in high school are examined with reference to the selection of freshmen in Brown University and their academic achievement. In a chapter devoted to criteria for the retention and dismissal of freshmen the value of psychological tests and academic grades is discussed. A section is also devoted to the adaptative and predictive value of general academic averages and of grades in specific subjects of the curriculum.

The conclusions drawn from this careful analysis can be briefly, and perhaps inadequately, summarized as follows: Psychological tests have been found to possess practical value as administrative aids at Brown University. They constitute one of the best available means for determining scholastic ability. *On the basis of what students have done in the past* it is possible to state quite definitely what kind of academic work one has a right to expect on the average from a student who makes any given psychological score. Students

with low academic grades are in general those with low psychological scores, and *vice versa*. Men receiving low psychological scores are shown to have practically no chance whatever of obtaining academic honors. The high school principal's estimate of a student is of little value in indicating what a student will do at college. A student's rank in high school at graduation is of greater predictive value, but it is not as reliable an index as the score in the Brown or Thorndike tests.

Coupled with poor academic work at the end of the first semester, a low psychological score is a just criterion for dismissing a man from college at that time. Of great interest is also the conclusion that a student's general academic grade at the end of his first semester is a very accurate index of what he will do during the second, and similarly there is a clear agreement between academic average for the freshman and sophomore year, although the grades received in a specific subject during the first semester vary pronouncedly in their prognostic value in respert to both high and low grades.

The general problems for the college are *selection* and *conservation*. More careful selection together with more effective guidance and supervision has already made notable progress at Brown University. Its work shows that there is no single test or criterion that can accurately estimate a candidate's fitness to do the academic work required at college and the desirability of retaining him at college. Many kinds of information must be obtained. Each kind must not, however, be given the same weight. The weight to be given can only be determined by a careful investigation such as the present one.

The second part of this volume represents one of the most important contributions which has been made in the field of selection and guidance of college students. Its value lies in the painstaking statistical analysis of a set of data and the well balanced interpretation of this data in the light of conditions existing in a given university. In spite of his very evident interest in the intelligence examination, the author weighs and interprets impartially the results of the statistical analysis of the validity of the more usual criteria. The same impartiality of judgment is not so evident in the first part of the book. Here the author tends both in content and interpretation to slight the cases which throw discredit upon the value of the intelligence test. It is true that in Table I (page 29) are presented a number of cases of low correlation between tests and academic standing, but this is followed by a long explanation of why a low correlation may have no significance. It is in the implication in this respect and in others, more

than in the fact of the treatment, that this tendency is revealed. The author also shows an occasional weakness in theory (as contrasted with technique), as for example, when he states that (page 28) "before casting aside such correlations as being too low to be significant we must bear in mind that these have been computed between intelligence scores and intelligence grades and not between two sets of intelligence tests nor between two sets of academic grades. In the two latter instances, one would be justified in expecting much higher correlations," and again when he quotes Miller as aptly pointing out that (page 32) "the more precisely a test measures intelligence the less will it correlate with academic standing" while he blithely devotes the rest of the book to the defense of the "intelligence" test as an indicator of academic standing.

The book closes with a bibliography of 294 titles of intelligence of college students.

MORRIS S. VITELES

University of Pennsylvania

PLATT, CHARLES. *The Psychology of the Social Life.* N. Y.: Dodd, Mead, 1922. Pp. 284.

WEEKS, ARLAND D. *The Control of the Social Mind.* N. Y.: Appleton, 1923. Pp. xviii+263.

These two books represent attempts to popularize social psychology. The first is written by a physician who also has a Ph.D. degree. He gives his book the subtitle "A Materialistic Study with an Idealistic Conclusion." Very few professional psychologists or sociologists would regard the book as especially materialistic, either in its beginning or in its conclusion. The author tells us that society is "a derivative from man's psychic need," and he rightly says that "society and the individual present but two sides of the same problem." The materialistic element in the book, if there be one, appears in the acceptance of the doctrine that instincts are "independent of all mental quality"; and the author starts the social life of man, rightly enough, with the human instincts. His doctrine of instinct is, however, very uncritical. Apparently he is not disturbed by the wordy war which has been going on over this psychological category for the last decade. He accepts the gregarious tendency as the source of man's social life, supplemented, of course, by the instincts of sex, fear, and combat. Habit, imitation, custom, tradition, and convention also play large rôles in human society, and

the same is true of sympathy, suggestion, hysteria, superstition, and error. The first part of the book is taken up with the discussion of these psychological factors, and the second part with applications and conclusions to the theory of society and to the problems of modern civilization. The problem of modern civilization, the author thinks, is due to the fact that man as an individual grows only through slow evolutionary changes, while society is saltatory in its movements. Hence, there is little wonder that man is not well adjusted to the society he himself has produced.

There is little new in Dr. Platt's book. Both its psychology and its sociology are rather thin, and in both subjects it is impossible to decide clearly which school he has followed. In the main, he seems to have followed James and McDougall in psychology, and Ross in sociology.

It can hardly be said that Professor Weeks, who holds the position of dean of the School of Education of the North Dakota Agricultural College, is any more successful in his attempt at the popularization of social psychology. He gives his book the subtitle, "Psychology of Economic and Political Relations," but the psychology again is inadequate. The author does not even tell us what he means by the "social mind." This is perhaps wise, because any attempt at definition of such a term might lead into difficulties, and detract from the popular presentation. Like the author of the first book, Professor Weeks also accepts uncritically some current biological views of human nature. He tells us, "we share in the inheritance of the prehistoric mind—the mind of the cave man, and the raw-meat eater, the hairy man." Nevertheless, he says, "In the sense that instinct is attributed to animals, man is almost without instincts." He holds very rightly that "learning is the greatest human fact." With this point of view he dilates upon the social significance of habit, the psychology of defense, the basis of coöperation, and the psychology of public business. In the second part of the book, he discusses more concretely the problem of social control. As would be expected from his point of view, he finds in education the chief agency of control. "Education is the most fundamental government." But the concrete conditions of life must also be controlled if we would control properly the social mind. "The large problem of society," says the author, "is to provide joyous outlet for inherited tendencies, and constructively to redirect such expressions of instinct as are not in harmony with rational program." All of this is, of course, wholesome, but it scarcely penetrates beneath the

crust of our social order to the real problems which lie underneath. Both of these books will have a wholesome influence, but the popularization of the social sciences, and of social psychology in particular, awaits the work of some more masterly hand.

CHARLES A. ELLWOOD

University of Missouri

STRATTON, GEORGE MALCOLM. *Anger: Its Religious and Moral Significance.* N. Y.: Macmillan, 1923. Pp. x+277.

This is a monograph of exceptional psychological and sociological importance. In the opinion of the reviewer (who writes with a sociological bias) it is a model of what a psychological monograph, especially when it is the study of some single aspect of human behavior, should be, because it presents, not simply the results of introspection and laboratory experiment, but also a survey of literature and of objective social life. Probably, however, the book will be ignored both by psychologists and by sociologists who taboo any possible approach to their subjects from the side of religious psychology. It is, however, a scholarly work in the best sense of that term, and throws light not only upon the human mind, but also upon human society.

Professor Stratton begins his study with a psychological and ethical survey of the beginnings of anger, its social utility, and its place in morals. He then turns to a study of the place of anger, in contrast with love, in the great historic religious faiths, such as Judaism, Zoroastrism, Mohammedanism, Taoism, Vishnuism, Buddhism, Confucianism, and Christianity. He contrasts the martial religions, which glorify anger, such as Mohammedanism, with the "unangry" religions, such as Buddhism, and then with the religions of anger-supported love, such as Confucianism and Christianity. The result is that the author shows us in a very vivid way, not only the part which anger and love have played in religion, but also in human social life. Surely this is inductive science at its best and sanest.

The book closes with a discussion of the future of anger in western civilization. The author shows clearly that the better trend of our civilization, indeed its stronger, more normal trend, is to subordinate anger to love or good-will; but he also shows that good-will needs the motivating power of anger in its contest with the evils which prevent the best development of mankind. Here, then, is another scientific book, which, in its contention that we can and

should make anger a true servant of good-will, and that we need a religion of anger-supported love to dominate all of our institutions before we can have a right culture, closely approaches the social and religious attitude of Jesus. But perhaps this is its condemnation!

CHARLES A. ELLWOOD

University of Missouri

FORD, JAMES. *Social Problems and Social Policy.* Boston: Ginn, 1923. Pp. xiii+1027.

This book is made up of one hundred and thirty-two selections on the treatment and prevention of poverty, defectiveness, and criminality. Professor Ford has prefaced the book by a brief introduction of seven pages. Part 1 deals with social ethics, Part 2 with social methods, Part 3 with the problem of defectiveness, Part 4 with the problem of poverty, and Part 5 with the problem of criminality.

As a reference book this volume is valuable, for the selections have been carefully chosen, many of them are not easily accessible to the student in any other form, and nearly all of them were written by men whose works are still regarded as authoritative. Professor Ford has therefore performed a valuable service in bringing these selections together. The book is obviously intended not only for reference, but also as a textbook. Opinions will, perhaps, disagree as to whether suitable textbooks in the social sciences can be produced in this manner; but until they are produced in some better way, texts of this sort will have undoubtedly a considerable value.

CHARLES A. ELLWOOD

University of Missouri

DUMAS, GEORGES. *Traité de Psychologie.* Vol. I. Paris: Alcan, 1923. Pp. xiv+964.

The present work represents a noteworthy advance in a new direction in the presentation of psychological knowledge. Modern psychology with its increasing ramifications of research and its growing specialization is yielding a very profuse and varied fund of knowledge. This condition has rendered it impossible for any single individual to master the developments in all of the various branches. Yet, hitherto, the conventional manner of covering this extensive field has been through the textbook, which, however excellent it might be, always revealed the imperfections contingent on the impossibility

of one or two authors understanding the fullness of psychological knowledge. The *Traité de Psychologie* is a serious and careful attempt to fill this gap left by the failure to bring together the fruitful results of the different lines of psychological development. It is the work of a group of twenty-five French scholars collaborating under the editorship of Georges Dumas, Professor of Experimental Psychology at the Sorbonne. To each scholar was assigned the preparation of a topic on which he was a specialist. In this manner there has been produced a work marked by an authoritativeness and a thoroughness of content which should gain for the production a wide adoption.

The *Traité de Psychologie* appears in two volumes, the first of which is discussed in the present review. The plan of presentation has been to proceed from the simple to the complex. The first volume is conveniently divided into four books, each containing a number of related chapters. Each chapter, usually the work of a single individual, endeavors to present a precise exposition of the actual knowledge on that division of psychology; and, in addition, includes a detailed bibliography of the most important works in all languages, and also makes many suggestions for further researches.

Following an interesting preface by the late Th. Ribot, there appears the introduction contributed by André Lalande, Professor of Methodology of Sciences at the Sorbonne, dealing with the different aims of pyschology and the various methods which may be employed. The bulk of the discussion is concerned with a satisfactory adjustment of such methods as introspection, comparison, and laboratory experimentation. The first book of the volume, bearing the caption, " Conceptions preliminary to the Study of Psychology," is devoted to the exposition of morphological, neurological, and biological conceptions which form a necessary introduction to the study of human psychology. Et. Rabaud, Professor of Experimental Biology at the Sorbonne, contributes the first chapter, which deals with man's position in the animal series and with his morphological development. Then comes the contribution of L. Lapicque, Professor of General Physiology at the Sorbonne, who is concerned in establishing the relation between intelligence and the weight of the brain, in the animal series in general, and in man and woman in particular. J.-P. Langlois of l'Académie de Médecine follows with a discussion on the general physiology of the nervous system, in the course of which he considers the neurone, nerve excitation, nerve conduction, and cerebral behavior. The nature of the nervous system

is delved into in a more minute manner in the succeeding chapter, written by A. Tournay, assistant in comparative histology in the Collège de France. Drawing heavily on the science of physiology, he presents a detailed description of the nervous system. The concluding chapter of the first book contributed by Henri Wallon of l'Institut de Psychologie of the University of Paris, is a rather thorough consideration of consciousness from a biological standpoint. It endeavors to make an adjustment in the dualism of mind and body.

The second book of the volume is entitled, "The Elements of Mental Life." It considers the sensory or motor states which constitute such elements: simple reflexes, conditioned reflexes, sensations, emotions, etc. It begins with a thorough and, in all respects, excellent chapter on "Excitation and movement." The writers are Georges Dumas, editor, and H. Piéron, physiological psychologist at the Sorbonne. Careful attention is given to reflex movements, to the phenomenon of inhibition, to muscular contraction, to tonus, and to voluntary movements, for, as the authors say, all of these play a considerable part in the adaptation of the physiological life to the social life. The succeeding chapter on "Sensations" is the contribution of B. Bourdon, Professor of Philosophy in the University of Rennes. It is a conventional treatment of touch, sight, hearing, etc., made with fine detail, but, adding nothing of note. Its consideration in the light of the "Gestalt" psychology would be interesting. Next follows a comprehensive section on the affective states, written by L. Barat (revised by the editor) and by L. Dugas, Professor of Philosophy in the Lycée de Rennes. Pleasure and pain, the emotions, and the passions are given consideration with the main emphasis placed on their physiological aspects. "Imagery" is the topic of discussion in the next section, written by L. Barat and revised by I. Meyerson of the Sorbonne. The relation of images to thoughts and to sensations is the main theme, with the stress again directed to the physiological side. As a concluding section to Book II is a very interesting chapter, written by Andre Mayer of the Collège de France, on the influence of perception, imagery, sensations, and affective states on glandular secretions. The fruitful results which this new field promises to yield make the inclusion of this chapter especially noteworthy.

The third book of the volume carries the title, "The Sensory-Motor Associations." It begins with a thorough consideration of "Orientation and Equilibrium," ranging in content from the internal

adjustment of the various parts of the body to the "homing" sense in man. Ed. Claparède, Professor of Psychology at the University of Geneva, and G. Dumas, the editor, have written the chapter. The second chapter on the expressions of emotions, written by the editor, is the most complete and most satisfactory discussion of this difficult topic so far encountered by the reviewer. A too prompt acceptance of Cannon's work (now being seriously questioned) alone mars the presentation. G. Dumas has also contributed the following chapter on "Laughing and Weeping," which, after presenting the physiological bases of both, ends in a theoretical tag after these ever elusive and tantalizing topics. A chapter on the important topic of Speech by L. Barat (revised by Ph. Chaslin) dealing with spontaneous language, articulate language, and the relation of language and intelligence concludes Book III.

The fourth book considers the "General Forms of Organization," touching on such topics as habit, memory, attention, and association of ideas. The analysis of these topics should constitute a natural transition between the study of the elements of mental life and the study of the particular functions of mental life. In the chapter on "Habit and Memory" H. Piéron (mentioned above) sets forth the forms, laws and rôle of memory in a very detailed and satisfactory manner. The discussion on the "Association of Ideas" has been contributed by J. Dagnan and G. Dumas. It is the usual discussion on a topic which tends to became antiquated: the nature of association, the factors of variation therein, and the relation of the affective states to the association of ideas. Chapter III on "Attention" has been written by G. Revault D'Allonnes. Starting with the view that attention is a choice, largely guided, however, by interest, the author passes to the different forms of attention, the sensori-motor basis of attention, the measuring of attention, and the pathology of attention. It represents the traditional consideration of this topic, done, however, in greater detail and condensed into a unique synthesis. The final chapter of the book is contributed by the reputable Pierre Janet. It is entitled "Psychological Tension and its Oscillations." Following an elaboration of the nature of the "tension," Janet concludes with a discussion of how it is affected by age, depression, excitability, sleep, fatigue, etc. This chapter brings the volume to a close.

The reviewer has refrained from making any criticisms of the content of the volume but has been desirous instead to indicate the nature and extent of the materials covered in this important work. In rounding out a judgment several points demand consideration. For

one thing, one should note that the volume as a whole offers nothing strikingly original in content. It serves more as a sketchmap of a field which has been previously surveyed; and while it is fertile in suggestions pertaining to topics of further investigation, it does not aim to present new theories or unique contributions. Further, as one would naturally suppose in a collaboration of many scholars in such an undeveloped science as psychology, the work is not always marked by a consistency in point of view or in theoretical presentation. Yet any deficiency in unity of content is compensated by the even more valuable unity of aim and method. Despite whatever the volume may lack in the way of originality or unity of content, it justly deserves to rank as the most important attempt at a comprehensive synthesis in the field of psychology which has been made, either here or abroad. Its thoroughness of elaboration, richness of detail, and unity of relationship should make the work indispensable for those who desire easy access to concise and adequate knowledge of psychological data and theory. The work is bound to be of great value to professional psychologists, alienists, neurologists, and social scientists—in fact to all who have been struggling to keep abreast of developments in a science whose extent prohibits individual mastery. A second volume promised for early publication should make the two serve as a veritable small encyclopedia.

HERBERT BLUMER

University of Missouri

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NOTES AND NEWS

DR. W. H. PYLE, of the University of Missouri, has gone to Teachers' College, Detroit, to carry on research and teaching on the psychology of learning.

THE National Research Council at Washington, D. C., has recently organized a Committee on Child Development with Professor Bird T. Baldwin, Director of the Child Welfare Research Station of the University of Iowa, as its chairman. Invitations have been issued to twenty-five leading specialists in the United States and Canada in anthropology, nutrition, pediatrics, psychology and psychiatry to meet in conference in New York, October 23, 24 and 25. A comprehensive research program in child development based on experimental procedure over a period of years and on the integration of allied sciences will be discussed and formulated.

THE Sixth International Congress of Philosophy will be held, under the auspices of the American Philosophical Association on September 13–17, at Harvard University, Cambridge, Mass. The sessions of the congress will be held in four divisions: 1. Metaphysics; 2. Theory of Knowledge, Logic and Scientific Method; 3. Theory of Values; 4. History of Philosophy. For information write the corresponding secretary, Professor John J. Coss, 531 West 116th Street, New York City.

DR. EDWIN M. BAILOR has been appointed assistant professor of psychology at Dartmouth College.

MR. EDWARD B. GREENE, formerly of the Department of Employment of the Western Electric Company, has been appointed instructor in psychology at Wesleyan University.

ON October 15, Professor Pierre Janet, of the College de France, lectured before the combined seminars of the psychological laboratory of the University of Pennsylvania on A Behavioristic Interpretation of the Sentiments.

THE following awards have been made from the Milton Fund for Research at Harvard University: to Walter F. Dearborn for an investigation of the mental and physical development of school children and to William McDougall for his investigation on the transmission of acquired characters.